

Conducted Electrical Weapon Use by Law Enforcement: An Evaluation of Safety and Injury

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Introduction: Controversy persists over the safety of conducted electrical weapons (CEWs), which are increasingly used by law enforcement agencies around the world. The purpose of this study was to examine injury patterns and physiologic conditions after CEW use under real life conditions.

Methods: A retrospective, cohort design was used, examining all CEW uses by one police department during a 6-year period. Data were collected from use-of-force forms and medical records and included conditions surrounding the use of force, medical histories, and data from emergency department evaluations and hospital admissions.

Results: Of 1,101 individuals subjected to (Taser M26 and X26) CEW use during the study period, 92.6% were male, the average body mass index was 26.2, and the age range was 9 to 73 years. Of the 886 (80.5%) with medical records, 46.8% had a psychiatric history and 72.9% had a substance abuse history. Emergency department (ED) evaluations occurred for 295 (26.8%) incidents. Of chief complaints, 41.7% were trauma related, 26.8% were for altered mental status, and 21.7% were for psychiatric evaluation. On presentation, 17.6% had a pulse >120, 1.7% were febrile, and 30.9% were altered; 1.4% met criteria associated with "excited delirium." When laboratory workup occurred, 70.6% had positive urine toxicology and 44.8% had positive alcohol levels. Troponin I was positive for one patient. Other laboratory abnormalities were rare, although extensive evaluations were infrequently done. Admission occurred in 24.4% of ED presentations (6.5% of all subjects); of discharge diagnoses for these patients, 59.7% were psychiatric, 22.2% were for unrelated trauma, 11.1% were for restraint-related trauma, and 6.9% were for unrelated medical diagnoses. No patients died.

Conclusions: Significant injuries related to 6 years of law enforcement CEW use in one city were rare. A large percentage of those subjected to CEW use had diagnoses of substance abuse and/or psychiatric conditions. Most admissions after CEW use were unrelated to law enforcement restraint.

Key Words: Conducted electrical weapons, Law enforcement, Taser.

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Despite a significant and growing body of research on conducted electrical weapons (CEWs), controversy persists over their effect on human physiology and the safety of their extensive and expanding use by law enforcement agencies.^{1–7}

The controversy related to CEWs is due to numerous factors, including conflicting modeling and laboratory results,⁴ an inability to recreate real-world conditions in the laboratory,^{1,6} and questions raised about research performed with industry funding.⁸ Critically, however, two key pieces of data in the debate remain limited: data showing the true frequency of adverse events and medical conditions associated with the weapon in real situations and an evaluation of situations when adverse events associated with CEWs occur.

Large-scale studies have begun to address these issues. The National Institute of Justice has gathered information on what types of encounters lead to CEW use based on law enforcement "use of force" documentation.⁹ Another article has presented 426 law enforcement CEW events but relied on law enforcement medical directors' evaluation of injury reports, rather than specifically examining the medical record.¹⁰ A more recent study observed six departments' use of CEWs >3 years.¹¹ Because significant injuries from CEW use are not common and each law enforcement agency's policies and culture of use could effect outcome from weapon discharge, further study is warranted.

The purpose of this study is to evaluate one police department's experience with CEW use from its inception during a 5-year period. By examining both law enforcement and medical records, we hoped to add to the data on the types and conditions of individuals who are restrained using CEWs and add specifics about the medical conditions of subjects after CEW use in a department different from prior studies.

MATERIALS AND METHODS

Study Design, Setting, and Participants

This study used a retrospective cohort design covering the period from January 1, 2001, to December 31, 2006.

Inclusion criteria were all cases of CEW discharge by the Seattle Police Department (SPD) during the study period. Exclusion criteria were CEW use on non-humans (e.g., animals) or on subjects who were never identified (e.g., escaped or released without identification) because no medical records could be researched for these subjects.

The SPD has jurisdiction over the entire city of Seattle. Seattle has an area of approximately 85 square miles and a

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population of approximately 582,000 (from the 2006 census estimate). Seattle's racial composition is approximately 70.1% white, 13.1% Asian, and 8.4% black; children and adolescents (younger than 20 years) make up 23.7% of the population and 12.0% are 65 years or older.¹²

The SPD has 1,203 officers currently in service. SPD uses Taser M26 and X26 weapons (Taser International, Scottsdale, AZ). Use of these CEWs was phased in starting December 2000 with 130 M26 weapons issued by early 2001. By 2004, 220 devices had been issued. In September 2005, a transition to X26 weapons began, leading to deployment of 311 × 26 models and 13 M26 models by 2006.

Briefly, the Taser M26 and X26 are hand-held, gun-shaped weapons, which fire two dart-like electrodes up to 35 feet, propelled by compressed nitrogen and connected to the weapon by insulated wires. Barbs at the end of the electrodes contact the skin or clothing of the target and an electrical circuit is formed. A high-voltage, low-amperage pulsed current is delivered, disrupting skeletal muscle function between the barbs and functionally incapacitating those muscles while the current is delivered. The device itself has exposed contact points that can also be directly applied to a subject in "stun mode" for "pain compliance" without disruption of muscular function. Detailed descriptions of CEW function have been well described in prior articles (e.g., Refs. 13–15).

Officer training for Taser use involves an initial full-day training with yearly half-day recertification, involving lecture, written testing, and hands-on exercises. Instruction on identifying individuals at high risk for sudden death is included and emphasized.

The use of force policy of SPD allows CEW use when it is "necessary and reasonable" as part of an escalating spectrum of less-lethal force options and in particular to overcome a subject's combative intent or resistance, to control persons trying to harm themselves or others, or to provide self-defense. Use in stun mode is considered a lower level of force (akin to other "pain compliance" techniques) than use in dart mode, because of the "greater risk of injury" associated with the latter, especially secondary injuries related to falls. The policy emphasizes particular consideration before using a CEW on the very old or young, pregnant, restrained, drug-using, or medically debilitated patients.

An initial medical directive required emergency medical service personnel on scene for subject evaluation after every CEW discharge. In December 2002, the directive changed to leave the decision for medical evaluation to the officers on scene but required EMS evaluation for all dart removal. In April 2005, it was added that EMS is required for more than three applications of a CEW weapon or special circumstances (pregnancy, extremes of age, etc.). Individuals who are evaluated on scene and require further medical attention are brought to the county hospital by protocol.

Data Collection

All uses of CEWs were prospectively identified by the SPD as part of their ongoing quality assurance program. For each use, the standard SPD "use of force" form was completed including narratives from all officers involved in the circumstances and a summary of events by the supervising

officer. Data on race, gender, age, height, weight, suspect mental condition, type of incident, number and location of weapon applications, effectiveness of applications, and associated injuries were collected and recorded by the department. Individuals were studied separately as adults, pediatric/adolescent (age <20 years), and in total, as in prior articles studying violence involving youths.¹⁶

For all individuals identified by SPD, medical record searches at the two public hospitals were performed. All searches occurred at least 1 year after the recorded CEW use. Any record of illicit substance abuse, diagnosed alcohol abuse, or diagnosed mental illness was identified.

The decision to transport for emergency department evaluation was made by EMS. Additional medical record searches at the county hospital where detainees are brought for evaluation occurred for all records of encounter within 24 hours of the CEW incident. For these records, data were collected from the emergency department notes and nursing records, and, if admitted, inpatient evaluation and treatment records and discharge summaries. These data included initial vital signs, mental status, laboratory results and discharge diagnoses. Most patients evaluated in the emergency department also had records of EMSs evaluation and transport; in these cases, data on field vital signs were also collected.

Patients displaying the symptoms associated with a higher risk of in-custody sudden death¹⁷ were identified and exact details of their law enforcement encounter and hospital course were collected.

The study was approved with a waiver of consent by the lead author's home institution's Human Subjects Division.

Data Analysis

All data were entered into a spreadsheet (Microsoft Excel X for Mac, Redmond, WA) and analyzed using descriptive statistics (SPSS, ver. 16.0, Chicago, IL). Data were also analyzed for adolescents and adults separately.

RESULTS

During the study period, there were 1,123 individuals against whom a CEW was used. Of those 22 (1.96%) were a "John Doe" or dog and were, therefore, excluded as no associated medical information could be obtained.

The demographics of the subject population are listed in Table 1. Subjects ranged in age from 9 to 73 years. The pediatric/adolescent group consisted of 59 subjects (53.6%) aged 18 or 19 years; 39 subjects (34.5%) aged 16 or 17 years; 12 subjects (10.9%) aged 13 to 15 years; and 1 subject (0.9%) aged 9 years. The majority of subjects were black, more noticeably so in the pediatric/adolescent population. Weight and body mass index varied greatly but generally reflected larger body types, with an average weight of >80 kg.

Of the 1,101 subjects, 295 (26.8%) were seen in the ED within 24 hours of the incident. An additional 571 (51.9%) patients had available medical records from other visits (Table 2). Among all patients with available medical records, 832 (93.9%) had either a history of drug or alcohol abuse or a psychiatric diagnosis (Table 3).

For the patients seen in the ED, patients at triage tended to be normotensive, tachycardic, normothermic, and alert.

TABLE 1. Demographics

	Total (N = 1,101)	Adult (N = 990)	Ped/Adoles (N = 111)
Age (yr)			
Range	9–73	20–73	9–19
Average (standard deviation)	32.0 (10.7)	33.7 (10.0)	17.4 (1.8)
Gender (%)			
Male	92.6	94.4	92.4
Race (%)			
Black	45.7	44.8	55.5
White	41.7	43.1	30.0
Asian	5.9	5.6	8.2
Other	6.5	6.5	6.4
Weight (kg)			
Range	41–223	41–223	41–136
Average (standard deviation)	83.2 (18.0)	84.3 (18.0)	73.5 (15.4)
BMI (kg/m ²)			
Range	14–67	18–67	14–48
Average (standard deviation)	26.2 (4.8)	26.5 (4.7)	24 (5.6)

Numbers do not always add up to 100 due to rounding.
Ped/adolesc, pediatric/adolescent.

TABLE 2. Medical Data Available

Record Available (%)	Total (N = 1,101)	Adult (N = 990)	Ped/Adoles (N = 111)
ED visit	295 (26.8)	271 (27.4)	24 (21.6)
Medical records only	591 (53.7)	534 (53.9)	57 (51.4)
No record	215 (19.5)	185 (18.7)	30 (27.0)

The distribution of available medical records for the subject population. “ED Visit” includes those who were seen in the ED immediately after the police encounter. “Med Rec Only” includes subjects who were not seen for their police encounter but had other medical records available. “No record” includes subjects for whom no medical records could be found.

Ped/adolesc, pediatric/adolescent.

TABLE 3. Psychiatric and Drug History

History (%)	Total (N = 886)	Adult (N = 805)	Ped/Adolesc (N = 81)
Psychiatric	415 (46.8)	386 (48.0)	29 (35.8)
Drug/alcohol	646 (72.9)	595 (73.9)	51 (63.0)
Psych or D/A	832 (93.9)	767 (95.3)	65 (80.2)
Psych and D/A	331 (37.4)	309 (38.4)	22 (27.2)

A history of psychiatric and drug or alcohol abuse history among all patients for whom medical records were found.

Ped/adolesc, pediatric/adolescent; Psych, psychiatric history; D/A and drug/alcohol, drug or alcohol abuse history.

The most common chief complaint recorded was altered mental status (26.8%) (Table 4). Prehospital vital sign values were similar to those seen in the ED (Table 5). ED evaluation frequently included urine toxicology (61.0%), blood alcohol level (61.4%), chemistries (47.1%), and a complete blood count or hematocrit (58.6%). Other laboratory studies were much less likely to be sent (Table 6). Only 24.4% of patients seen in the ED were admitted; of those, the majority (59.7%)

TABLE 4. Triage Data From ED Visits

	Total (N = 295)	Adult (N = 271)	Ped/Adolesc (N = 24)
Chief complaint (%)			
AMS	79 (26.8)	71 (26.2)	8 (33.3)
Psychiatric	64 (21.7)	56 (20.7)	8 (33.3)
Other med	29 (9.8)	28 (10.3)	1 (4.2)
Trauma	123 (41.7)	116 (42.8)	7 (29.2)
Systolic BP			
Range	72–206	72–206	96–168
Average (standard deviation)	139 (20.1)	140 (20.2)	136 (19.7)
IQ range	128–152	128–152	124–153
<90 (%)	3 (1.0)	3 (1.1)	0 (0)
Pulse			
Range	54–202	54–188	67–202
Average (standard deviation)	103 (22.7)	104 (22.0)	102 (29.0)
IQ range	89–115	90–115	84–116
>120 (%)	52 (17.6)	47 (17.3)	5 (20.8)
Temperature			
Range	33.5–39.5	33.5–39.5	35.7–38.5
Average (standard deviation)	36.3 (2.5)	36.3 (2.6)	36.6 (0.7)
IQ range	36.0–37.0	36.0–37.0	36.2–37.0
>38.4 C (%)	5 (1.7)	4 (1.5)	1 (4.2)
Mental status (%)			
Alert	204 (69.2)	185 (68.3)	19 (79.2)
Agitated	69 (23.4)	65 (24.0)	4 (16.7)
Lethar/obtund	22 (7.5)	21 (7.7)	1 (4.2)

Data from the triage notes from individuals evaluated in the emergency department. BP, blood pressure; AMS, altered mental status; other med, other medical problem; IQ, interquartile; lethar/obt, lethargic or obtunded; ped/adolesc, pediatric/adolescent.

TABLE 5. Prehospital Condition

	Total (N = 117)	Adult (N = 111)	Ped/Adolesc (N = 6)
Systolic BP			
Range	70–215	70–215	88–156
Average (standard deviation)	138 (24.6)	139 (25.2)	129 (17.7)
IQ range	120–151	120–155	118–142
<90	4 (2.4%)	3 (2.7%)	1 (16.7%)
Pulse			
Range	61–170	61–170	63–130
Average (standard deviation)	104 (21.6)	105 (22.1)	97 (15.9)
IQ range	88–120	88–120	88–103
>120	30 (25.6%)	29 (26.1%)	1 (16.7%)
Respiratory rate			
Range	12–48	12–48	12–24
Average (standard deviation)	19 (5.0)	19 (5.2)	18 (3.5)
IQ range	16–20	16–20	15–20
>20	20 (17.1%)	18 (16.2%)	2 (33.3%)

Data from available prehospital run sheets. BP, blood pressure; IQ, interquartile; ped/adolesc, pediatric/adolescent.

were discharged from the hospital with a psychiatric diagnosis (Table 7). No patients died in relation to CEW use.

Law enforcement CEW use tended to occur more frequently in the evening (43.6%) and night (34.2%). Use of

TABLE 6. ED Evaluation

	Total (N = 295) (%)	Adult (N = 271)	Ped/Adolesc (N = 24)
Toxicology (%)	N = 180 (61.0%)	N = 164 (60.5%)	N = 16 (66.7%)
Positive	127 (70.6)	115 (70.1)	12 (75.0)
Multi-positive	60 (33.3)	52 (31.7)	8 (50.0)
Cocaine	72 (40.0)	71 (43.3)	1 (6.3)
Amphetamine	35 (19.4)	29 (17.7)	6 (37.5)
PCP	8 (4.4)	6 (3.7)	2 (12.5)
Narc/ben/bar	47 (26.1)	42 (25.6)	5 (31.3)
Marijuana	47 (26.1)	39 (23.8)	8 (50.0)
Blood alcohol (%)	N = 181 (61.4%)	N = 167 (61.6%)	N = 14 (58.3%)
Positive	81 (44.8)	79 (47.3)	2 (14.3)
>100 mg/dL	64 (35.4)	64 (38.3)	0 (0)
pH (%)	N = 10 (3.4%)	N = 10 (3.7%)	N = 0 (0%)
<7.3	2 (20.0)	2 (20.0)	0 (0)
Lactate (%)	N = 5 (1.7%)	N = 5 (1.8%)	N = 0 (0%)
>2.1 mmol/L	3 (60.0)	3 (60.0)	0 (0)
Troponin (%)	N = 17 (5.8%)	N = 17 (1.8%)	N = 0 (0%)
Positive	1 (5.9)	1 (5.9)	0 (0)
Creatinine kinase (%)	N = 25 (8.5%)	N = 23 (8.5%)	N = 2 (8.3%)
>1,000 U/L	11 (44.0)	10 (43.5)	1 (50.0)
Potassium (%)	N = 144 (48.8%)	N = 134 (49.4%)	N = 11 (45.8%)
>5.4 mEq/L	2 (1.4)	2 (1.6)	0 (0.0)
Creatinine (%)	N = 144 (48.8%)	N = 134 (49.4%)	N = 11 (45.8%)
>1.2 mg/dL	38 (27.3)	34 (26.6)	4 (36.4)

Results from laboratory workup for individuals evaluated in the ED.
 Multipositive, positive for more than one substance; PCP, phencyclidine; Narc/ben/bar, narcotics, benzodiazepines, and/or barbiturates; ped/adolesc, pediatric/adolescent.

CEW was used less to catch individuals who had run away (24.2%) and more to stop a violent physical confrontation (37.1%) or control an individual who would not follow law enforcement issued commands (38.7%). Subjects were armed 21.3% of the time, most frequently with a knife (43.6%). CEW use tended to occur when there was more than one officer present; often there were four or more (37.2%). The suspected crimes for which individuals were being confronted when CEW use occurred varied widely; physical altercations and public disturbances were the most common (22.3%) (Table 8).

CEWs were used in dart mode most often (56.0%). For each CEW mode (stun or dart), only one discharge occurred approximately half the time. The effect on controlling the

TABLE 7. Admitted Patients

	Total (N = 295)	Adult (N = 271)	Ped/Adolesc (N = 24)
Disposition (%)			
Admission	72 (24.4)	68 (25.1)	4 (16.7)
Discharge dx (%)	N = 72	N = 68	N = 4
Psychiatric	43 (59.7)	40 (58.8)	3 (75.0)
Trauma—rest	8 (11.1)	8 (11.8)	0 (0)
Trauma—unrel	16 (22.2)	15 (22.1)	1 (25.0)
Medical	5 (6.9)	5 (7.4)	0 (0)

Discharge diagnoses among the patients admitted to the hospital.
 Trauma—rest, trauma occurring during law enforcement restraint; trauma—unrel, trauma unrelated to law enforcement restraint; ped/adolesc, pediatric/adolescent.

TABLE 8. Situation Surrounding CEW Use

	Total (N = 1,101)	Adult (N = 990)	Ped/Adolesc (N = 111)
Time of day (%)			
0001–0800	377 (34.2)	339 (34.2)	38 (34.2)
0801–1600	244 (22.2)	225 (22.7)	19 (17.1)
1601–2400	480 (43.6)	426 (43.0)	54 (48.6)
Suspect behavior (%)			
Run away	266 (24.2)	223 (22.5)	43 (38.7)
Struggle	409 (37.1)	372 (37.6)	37 (33.6)
Ignore command	426 (38.67)	395 (39.9)	31 (28.2)
Subject armed (%)	n = 234 (21.3%)	n = 211 (21.3%)	n = 23 (20.7%)
Gun	44 (18.8)	37 (17.5)	7 (30.4)
Knife	101 (43.6)	94 (44.6)	7 (30.4)
Other	89 (38.0)	80 (37.9)	9 (39.1)
Officers present (%)			
1	54 (4.9)	53 (5.4)	1 (0.9)
2	344 (31.2)	304 (30.7)	40 (36.0)
3	293 (26.6)	263 (26.6)	30 (27.0)
4	214 (19.4)	195 (19.7)	19 (17.1)
>4	196 (17.8)	175 (17.7)	21 (18.9)
Incident type (%)			
Drug related	174 (15.8)	106 (16.2)	14 (12.6)
Psychiatric	124 (11.3)	107 (10.8)	17 (15.3)
Violent crime	172 (15.6)	159 (16.1)	13 (11.7)
Fight/disturb	245 (22.3)	225 (22.7)	20 (18.0)
Property crime	125 (11.4)	106 (10.7)	19 (17.1)
Traffic stop	114 (10.4)	958 (9.9)	16 (14.4)
Other	147 (13.4)	135 (13.6)	12 (10.8)

Data from use of force reports about the conditions surrounding CEW use.
 Fight/disturb, fight or public disturbance; ped/adolesc, pediatric/adolescent.

individual was considered partial or completely disabling in 86.6% of all cases. CEWs were used on the chest and upper back most commonly (68.3%) (Table 9).

Four subjects met a large number of the criteria for “excited delirium” or high risk for restraint-related death (Table 10), including among other symptoms, agitation, above-normal strength, insensitivity to pain, and hallucina-

TABLE 9. Details of CEW Use

	Total (N = 1,101)	Adult (N = 990)	Ped/Adolesc (N = 111)
CEW application (%)			
Stun only	308 (27.8)	282 (28.5)	26 (23.4)
Dart only	614 (56.0)	550 (55.6)	64 (57.7)
Both	179 (16.3)	158 (16.0)	21 (18.9)
Stun number/encounter (%)			
	N = 487 (44.2%)	N = 440 (44.4%)	N = 47 (42.7%)
1	251 (51.5)	228 (51.8)	23 (48.9)
2	141 (29.0)	128 (29.1)	13 (27.7)
3–5	72 (14.8)	65 (14.8)	7 (14.9)
>5	23 (4.7)	19 (4.3)	4 (8.5)
Dart number/encounter (%)			
	N = 793 (72.0%)	N = 708 (71.5%)	N = 85 (77.3%)
1	447 (56.2)	392 (55.1)	55 (65.5)
2	212 (26.7)	188 (26.4)	24 (28.6)
3–4	115 (14.5)	109 (15.3)	6 (7.1)
>4	19 (2.4)	19 (2.8)	0 (0)
Perceived effect (%)			
None	147 (13.4)	130 (13.1)	17 (13.4)
Partial	466 (42.3)	430 (43.4)	36 (32.4)
Disabling	488 (44.3)	430 (43.4)	58 (52.3)
Where hit (%)			
	N = 1,035	N = 936	N = 98
Chest/up back	707 (68.3)	629 (67.1)	78 (79.6)
Abd/low back	213 (20.6)	194 (20.7)	19 (19.4)
Upper ext/neck	234 (22.6)	214 (22.9)	20 (20.4)
Lower ext	291 (18.1)	31 (31.6)	260 (27.8)

Data from use of force reports about the conditions surrounding CEW use.
 Number/encounter, number of CEW discharges per encounter when each type was used; abd, abdomen; ext, extremity; Ped/adolesc, pediatric/adolescent.

tions. Each engaged in a struggle with multiple officers and was eventually evaluated in the emergency department. Three (I, III, and IV) were admitted to the hospital for observation; the other (II) was discharged to the county jail with a diagnosis of acute toxic encephalopathy. All three admitted patients had quickly normalizing mental status, vital signs, and laboratory studies, were observed for trauma-related injuries, and discharged after a brief observation period. One individual (I) seemed to have been at especially high risk for restraint-related death and did have evidence of cardiac injury. This 42-year-old gentleman was found by officers eating dirt and hitting himself with a rock. When he charged at officers throwing rocks, he received one CEW dart discharge and two stun discharges during the short struggle, before restraint was achieved. He arrived in the ED agitated, diaphoretic, tachycardic (157), febrile (39.5), and hypertensive (171 of 79). His urine toxicology was positive for marijuana, opiates, cocaine, methamphetamine, phencyclidine, tricyclic antidepressants, and amphetamines. Other key laboratory findings included an initial white count elevated at 30,600/ μ L, creatinine elevated at 1.8 mg/dL, a CO₂ level of 25 meq/L (normal), and an anion gap of 24; his creatinine kinase peaked at 20,200 U/L and his troponin I peaked at 3.9 ng/mL.

An electrocardiogram showed sinus tachycardia with no ischemic changes. The patient was given haloperidol and diazepam in the emergency department, became sedated, and ultimately returned to a normal mental status before admission. He was observed overnight and ultimately discharged with a diagnosis of polysubstance overdose.

DISCUSSION

This examination of 5 years of CEW use demonstrates a strong safety record. Only a quarter of subjects were deemed injured or sick enough to require ED evaluation; of those, only a quarter were admitted and only a 4.4% were admitted for restraint-related trauma or medical reasons.

Despite the low incidence of injuries found, our results differ notably from prior studies, which showed even lower significant injury rates. There are clear methodologic explanations for these differences. One study was based on interpretation of police data rather than medical records¹⁰; the other only looked at admissions that were clearly related to CEW use, but how this was determined was not defined.¹¹ We find this approach limiting as the full extent of physiologic impact from CEW use during restraint is unknown, and admissions for medical or other restraint-related trauma could be impacted by CEW use. The fact that more than 5% of the subjects in our study who were tested had evidence of rhabdomyolysis, acidosis, or a positive troponin raises the question of what role CEW use had in these findings that may not have been discovered in the other studies.

It is also important to note that the retrospective nature of this study may actually increase its ability to capture normal conditions, because the officers were following policies without concern that the effects of their CEW use was being specifically monitored.

The field data from this study are similar to previously published work in terms of subject gender, age, and size and indication for CEW use.^{10,11} No prior study has reported racial makeup of those exposed to CEWs. Our study showed that 46% of CEW uses involved black individuals, which is disproportionate to the general population in this study area. The racial breakdown in overall use of force and in arrests, particularly arrests for violent crime, by this department is very similar to that of CEW use,¹⁸ however, suggesting that there is no connection between race and CEW use in this law enforcement agency. Further study may be indicated, however.

This study is also notable for its inclusion of pediatric and adolescent individuals. Taser-related deaths in individuals younger than 18 years have been reported¹⁹ but make up a smaller number of cases, likely given the smaller number of juveniles committing major crime and requiring significant restraint. Although no increase in injury patterns were seen in this group in this study, given this smaller sample size, further research is clearly warranted and more discretion on CEW use should be used in the adolescent and child population until safety is validated.

The issues raised by the result obtained in this study begin to focus some of the broader questions surrounding CEW use: under what conditions is CEW use appropriate and how dangerous is use of CEWs on higher risk populations?

TABLE 10. High Risk Cases

	I	II	III	IV
Demographics				
Age	42	39	39	32
Gender	Male	Male	Male	Male
Race	White	Black	Black	Asian
BMI (kg/m ²)	22.0	36.6	32.3	21.0
Presentation				
Pulse	157	141	136	155
SBP	171	140	96	129
Temp	39.1	36.7	35.9	38.1
MS	Agitated	Agitated	Agitated	Alert
Key studies				
Toxicology studies	Cocaine, amphetamine, opiates, PCP	Cocaine	Cocaine opiates	Cocaine, marijuana, alcohol
WBC (/μL)	30,600	13,000	23,700	12,300
CK (U/L)	20,200	4,830	ND	ND
CR (mg/dl)	1.8	2.1	0.8	1.2
CO ₂ (meq/L)	25	18	26	10
Trop (ng/mL)	3.9	0.1	ND	ND
EKG	Sinus tachycardia	Nonspecific T-wave changes	ND	ND
Disposition				
Admission	Yes	No	Yes	Yes
Discharge	Acute toxic	Acute toxic	Rib fracture,	Motor vehicle
Diagnosis	Encephalopathy	Encephalopathy	Pneumothorax	Accident

Cases of subjects who displayed commonly sited behaviors and signs associated with high risk of restraint-related death including agitation, supernormal strength, insensitivity to pain, hyperthermia, attraction to shiny or bright objects, hallucinations, paranoia, diaphoresis, and incoherent yelling.

ND, not done; BMI, body mass index; WBC, white blood cell count; CK, creatinine kinase; CR, creatinine; Trop, troponin I; SBP, systolic blood pressure; temp, temperature; MS, mental status; EKG, electrocardiogram.

The overwhelming majority of subjects had psychiatric or substance-abuse problems, were acting erratically, or showed other risk factors associated with restraint-related (and CEW related) death.^{20,21} This is exactly the population who create arrest situations that are difficult or dangerous enough to warrant CEW use. That only four subjects over 5 years arrived at the emergency department with a large proportion of signs associated with “excited delirium,” however, suggests a few possible explanations: either the city in which the study occurred had an unusually low incidence of restraint of such individuals or the law enforcement agency’s training effectively allowed officers to identify high risk individuals and avoid CEW use in these circumstances. That one subject survived but was quite ill on arrival and had cardiac damage can be interpreted in many ways. On the one hand, CEW use did not cause a death in this high-risk subject; on the other hand, significant injury did occur, raising the question of the effect of the CEW on the patient’s condition. There is no way to measure the effect based on the current studies available.

Adding to the overall data on CEW use is important because controversy remains strong about CEW use by law enforcement. Accounts of CEW-related injuries or deaths seem in the popular press with great frequency; ensuing public outcry has caused high ranking officers to step down²² and in Canada caused consideration of a complete ban on the weapons.²³ The controversy continues primarily because of long-standing issues surrounding deaths and injuries associ-

ated with police restraint and conflicting research and claims associated with CEW use.

A contentious debate about restraint-related deaths has arisen during the last decade.^{24,25} Although certain suspect conditions (e.g., obesity and pre-existing cardiac disease) and behaviors often described as “excited delirium” (e.g., stimulant use, confusion, and violent behavior leading to long struggles) have been closely associated with deaths in many studies,^{24,26,27} many individuals with this constellation of symptoms do not die, and the actual significance and causal effect during restraint have yet to be shown.²⁸ Because conditions during restraint are dangerous, rarely directly observed by a medical professional, and described by participants whose culpability in the death is at risk, recreation of the events and finding causality are extremely difficult.^{21,28–30} Furthermore, it is unclear whether the effects of CEW use may compound other forms of force used during restraint, an unknown that deserves further study. Finding these relationships and causality is important.³¹ When long struggles occur, police have the very difficult task of balancing duties to protect the community, the individual being restrained, and the officers involved. Identifying individuals at risk and finding the best methods of restraint under these circumstances are critical to this balance.

The lack of definitive and often contradictory research attempting to demonstrate causality compounds the problem. A debate in the 1990s, which focused on restricted breath-

ing,³² and particularly suspect positioning and law enforcement holds³³ has turned to the effects of CEW use as the weapon has been adopted by most law enforcement agencies and more deaths have been associated with its use. Because these weapons involve electrical stimulation and loss of voluntary control of musculature, many different potentially lethal effects have been considered.

Physiologic studies initially focused on cardiac effects. Although some researchers have found no evidence of changes in electrocardiogram tracings,³⁴ echocardiographic changes,³⁵ or elevations in troponin,³⁶ others have reported QT prolongation,³⁷ potential to induce ventricular fibrillation,³⁸ case reports of direct cardiac effects,^{39,40} and theories of acute stress cardiomyopathy⁴¹ have led some experts to suggest that no conclusive results can be drawn as yet.⁴ More recently, studies have looked at effects on breathing and acidosis. Most studies show increased respiration, minimal effect on ventilation or oxygenation, and a measurable increase in acidosis of unclear clinical significance.^{42–46} Because laboratory conditions involve healthy human volunteers or swine who are not struggling and restraint has additional effects on breathing and acid-base levels,^{47–50} some authors have suggested that these physiologic changes could have catastrophic effects under real-life conditions,^{1,6} a question that remains unresolved.⁹

In any case, a close and continuing relationship between emergency physicians and law enforcement to establish and continually update policy is clearly warranted. An effective policy of prudent and safe CEW use has other advantages besides decreased injury during restraint and improved public opinion on the weapon. Ironically, CEWs seem to be attractive to the law enforcement community because they offer potentially safer alternatives to more traditional force options, such as batons or firearms, which have clearly established injury and consequence profiles. With a reasonably restrictive and careful proactive policy, there is an opportunity to make an impact on the long-standing concern about “excessive” use of force by police,^{51,52} which has been recently reignited by the introduction of CEWs. Given the high number of encounters for psychiatric reasons in this study where law enforcement is called to restrain an individual for his or her own protection, it would seem particularly prudent to have a “first do no harm” policy for CEW use itself.

One surprising finding from this study is the limited laboratory evaluations most subjects received on arriving in the ED; given the risks associated with CEWs, other authors have recommended more thorough toxicologic, cardiac, and metabolic evaluations.⁵³ Given the low overall injury rate, it would seem that a more selective approach to a comprehensive evaluation is reasonable. However, it is important to note that two of the patients identified as high risk for an in-custody death were evaluated without an electrocardiogram or cardiac studies and none had a pH or lactate, despite two showing evidence of acidosis. Although each of these patients was safely discharged, these results underscore the importance for emergency physicians to recognize patients at high risk for in-custody death, understand the mechanisms by which such deaths are thought to occur, and undergo the appropriate evaluations and treatments. This should include,

at a minimum intravenous access, oxygen, and extended, continuous monitoring, including core body temperature; arterial blood gas, troponin, creatinine kinase, electrolytes, and toxicology studies; and sedative or antipsychotic medical management as necessary.

This study had multiple limitations that could have affected its results. As a retrospective study, there is no way to demonstrate causality between CEW use and injury patterns. Cases that might have changed the results significantly could have been missed by the initial identification of CEW use cases by the law enforcement agency. It is also possible that individuals were taken to hospitals other than the county hospital where in-custody patients are taken by protocol; such a deviation should have been noted in the use of force records, however, and none were identified in this study. It is also possible that individuals in the field who did in fact need medical attention were not evaluated by medics due to a judgment call by officers on scene. In some cases, the medical or use of force information available may have been incomplete. Finally, the data presented here are for one city only with a unique law enforcement training program and general population; therefore, the data are not necessarily generalizable to all cities.

Our study found only limited injuries related to broad CEW use during a 5-year period by a single law enforcement entity. These data combined with other studies begin to suggest a good safety profile when the weapons are used appropriately in the general population. The low frequency of high-risk subjects in this and other studies make identifying individuals for whom CEW use may be lethal particularly difficult. Further studies should focus on law enforcement encounters that involve long struggles and high-risk individuals, comparing the safety of CEWs with other force options. A national database of CEW and other less-lethal weapon use would capture these infrequent cases and establish the best force options in high-risk situations.

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